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Designing and Testing Active Flow Control Systems at the Junction of Ultra-High Bypass Ratio Engines and the Wing

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This conference contribution will talk about applying Active Flow Control (AFC) at the junction between Ultra-High Bypass Ratio (UHBR) engines and the wing. The work described in this paper & the research leading to these results has received funding from the European Community's Seventh Framework Programme FP7/2007-2013, under grant agreement n° 604013, AFLONEXT project. The contribution will motivate the need for AFC in this application, will show the design and test strategy and will show some first results.

In civil aviation, Ultra High Bypass Ratio (UHBR) engines with very high "Bypass Ratios" (BR) and lower "Fan Pressure Ratios" (FPR) have a considerable potential for ecologic and economic benefit [1]. Already for the slightly smaller Very High Bypass Ratio (VHBR) engines the integration under the wing of current conventional aircraft under development (e.g. A320 NEO) is already challenging but becomes even more when novel aircraft configurations are considered, featuring highly integrated UHBR engines.

This challenge is driven by two aspects: firstly, at high angles of attack and low speeds current conventional aircraft with under-wing mounted engines are susceptible to local flow separation in the region inboard of the wing/pylon junction. This separation is triggered by interfering vortices [2] originating from the engine nacelle, the slat ends etc. Secondly, with larger engine nacelles it becomes more difficult to ensure sufficient clearance between the nacelle and the runway for the aircraft on ground. To evade longer landing gear struts suffering from weight and space penalties as well as an increased level of landing gear noise, the engine is closer coupled to the wing. The close coupling requires slat-cut-outs in the region of the wing/pylon junction in order to avoid clashes of the deployed slat with the nacelle. These slat-cut-outs further exacerbate the risk of the aforementioned separation. Possible consequences are the degradation of the effect of movables and the reduction of maximum lift, see Figure 1 and [3]. The maximum lift coefficient for the landing configuration and the lift over drag ratio for the take-off configuration are directly related to the achievable payload or flight range [4].

In current aircraft, the maximum local lift is significantly improved with strakes mounted on the inboard side of the engine nacelle. Yet, the aerodynamic effect of strakes is limited and for modern VHBR engines the problem of possible local flow separation persists [5] leaving further space for optimizing high-lift performance. With the upcoming introduction of highly efficient and ecologic UHBR engines, slat-cut-outs will likely become larger and the problem will even become worse. The objective of this project is to overcome the problem by actively suppressing the local flow separation linked to the wing/pylon junction by means of AFC through energizing the flow with fluidic jets. Two technological approaches are pursued: a) pulsed jet actuators with and b) without net mass flux (here: Synthetic Jet Actuators).

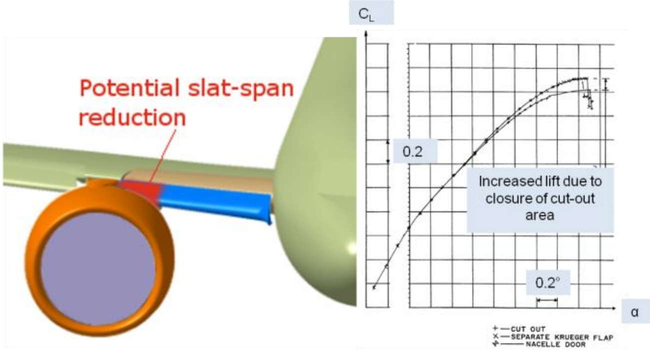

Figure 1: Effect of slat cut-out on lift curve.

For this study two reference configurations are used: the realistic configuration is based on Flugzeug Neuer Generation (FNG) with a representative UHBR engine and the baseline configuration is based on the SADE (Smart High Lift Devices for Next Generation Wings) windtunnel model modified to have a wing leading edge sweep. Both configurations have a representative UHBR engine installation. We use Reynolds Averaged Navier Stokes Equations (RANS) simulations to study the flow for the two configurations without AFC to cross-validate that the baseline configuration shows the relevant flow phenomena. Afterwards parametric RANS studies help to find the optimal actuator position and actuator parameters (jet velocity, jet actuation frequency, duty-cycle). These parameters along with many other requirements form the hardware specification. According to this specification actuators and other hardware are developed, groundtested and then installed into windtunnel inserts. These inserts fit into the modified SADE model for the technology readiness demonstration in the large-scale windtunnel. The realistic model scale and realistic flow conditions of the windtunnel testing allow demonstrating the maturity. Comparing the results to the ones gained for the realistic configuration with AFC helps to estimate the benefit on aircraft level.

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